

A 3D CAD model of a ventilator device, showing a blue base, a white top housing, and various internal components like a motor, gears, and a red button. The model is shown in a cutaway view. The title 'Columbia DIY Ventilator Challenge' is overlaid in large black text.

Columbia DIY Ventilator Challenge

Team Biryani

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The Team

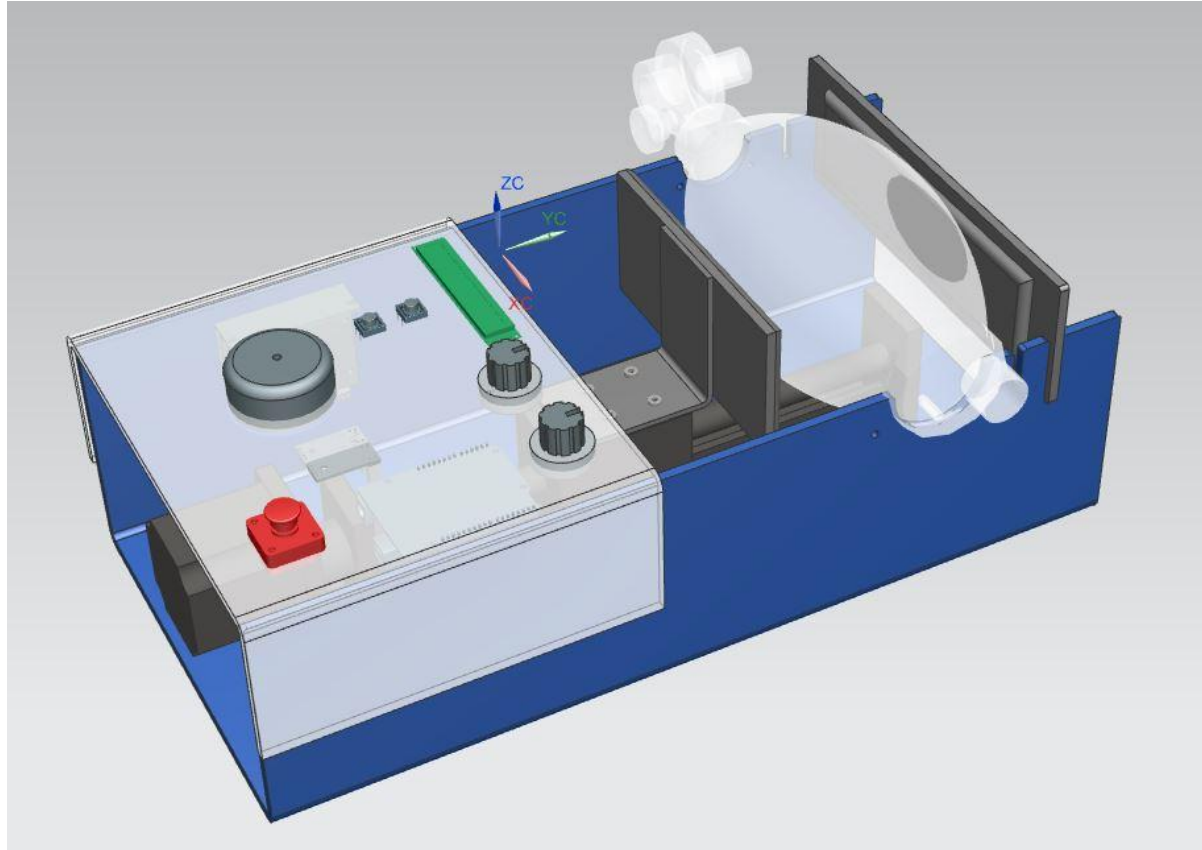
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Problem Statement and Solution

Due to the sudden COVID-19 pandemic outbreak and the imminent shortage of essential ventilator machines in New York City (and potentially in the United States), there is an urgent need for temporary makeshift ventilators that are easy-to-make, accessible and affordable for all.

Named the “DIY Ventilator”, our solution is a low-cost portable ventilator made from an automated mechanism squeezing an Ambu-Bag (or any similar BVM) at regular intervals to ensure consistent airflow to a patient in need of urgent ventilation, until a medical ventilator becomes available.

Overall Design



Overall Dimensions:

Height: 125 mm

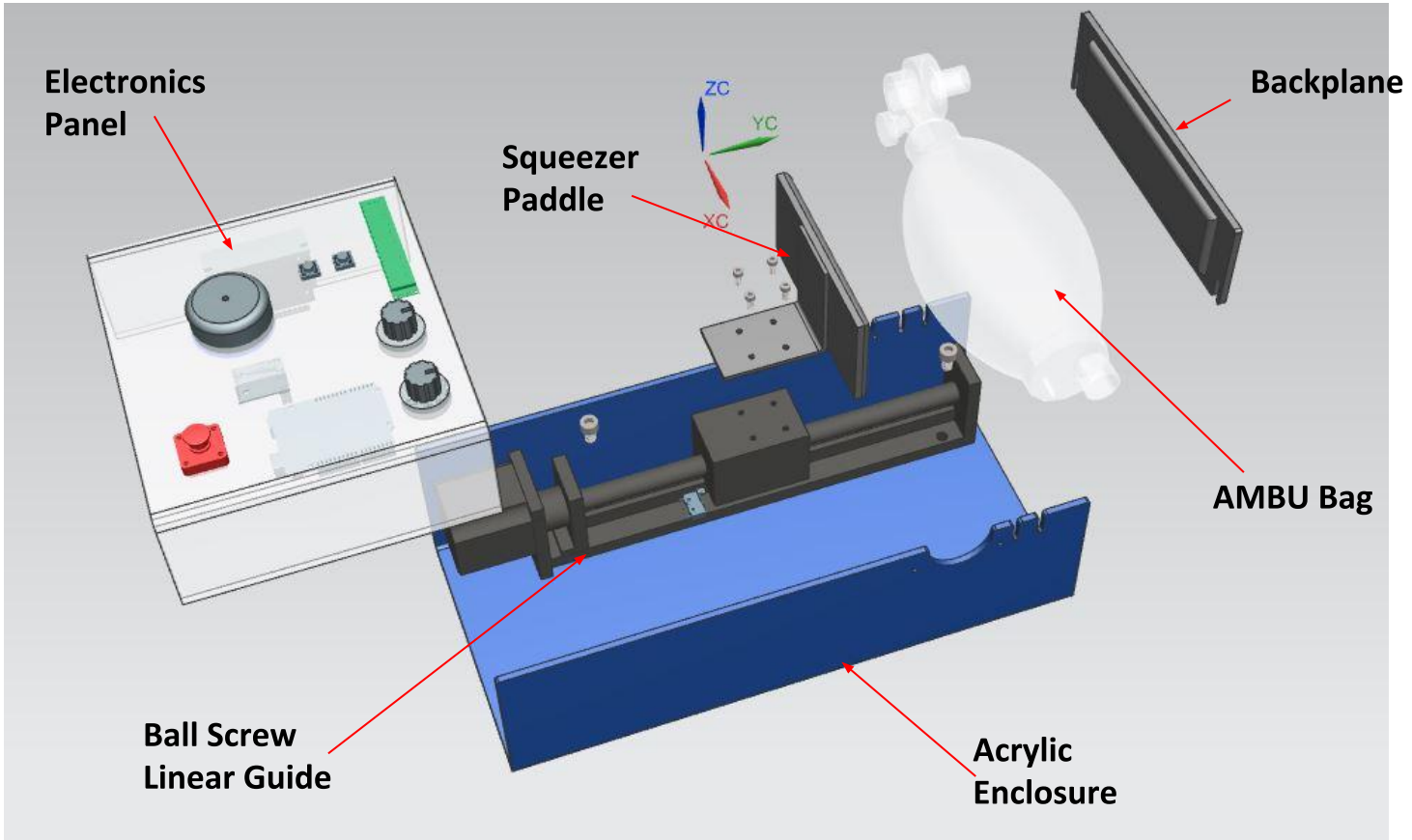
Width: 230 mm

Length: 450 mm

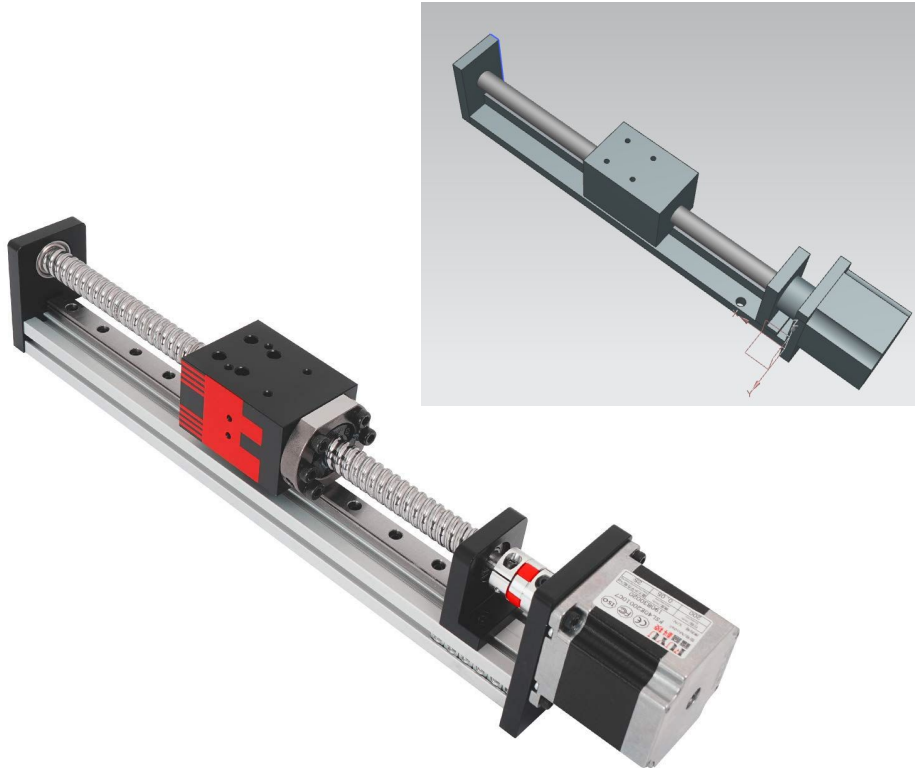
Weight: 10 lbs

(Approx)

Detailed Design - Exploded



Component Detail - Linear Guide Ball Screw



Off-the-shelf component - Available on Amazon, Ebay etc, variety of manufacturers

Specifications

Travel: 200mm

Max Load: 40 -50 lbs

Max Speed: 150mm/sec at full load

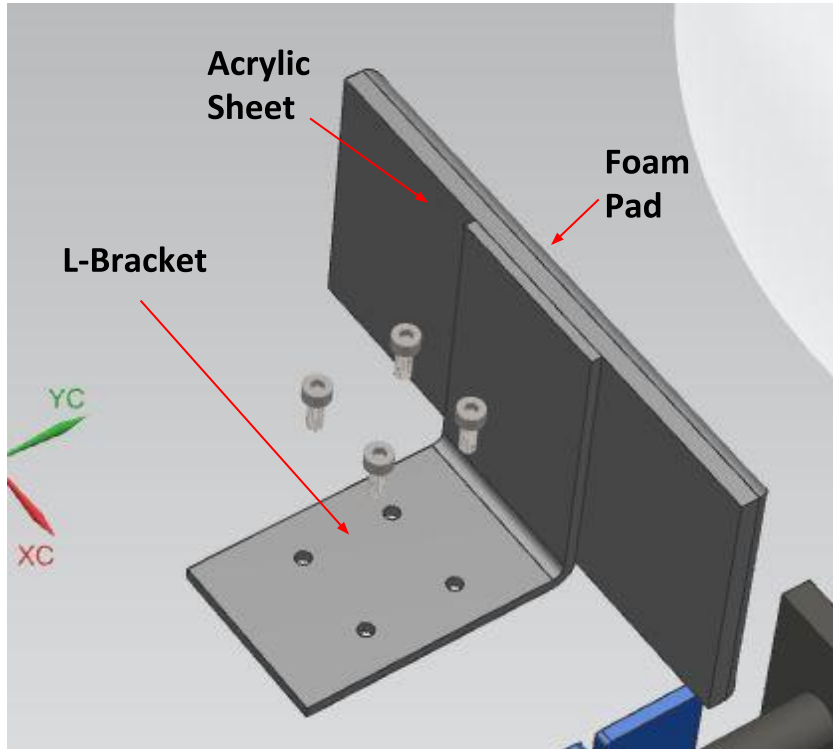
See link for video of movement:

<https://www.youtube.com/watch?v=Z7Ue73CAqeM>

Advantages:

- Off-the-shelf OEM component
- Reliable
- Long Duty Cycle
- Pre-assembled Mechanism
- Accurate

Component Detail - Squeeze Paddle



Off-the-shelf component with minor modifications

L-Bracket + Foam Padded Acrylic Sheet

Specs:

L-Bracket: Steel, 75mm X 60 X 50mm

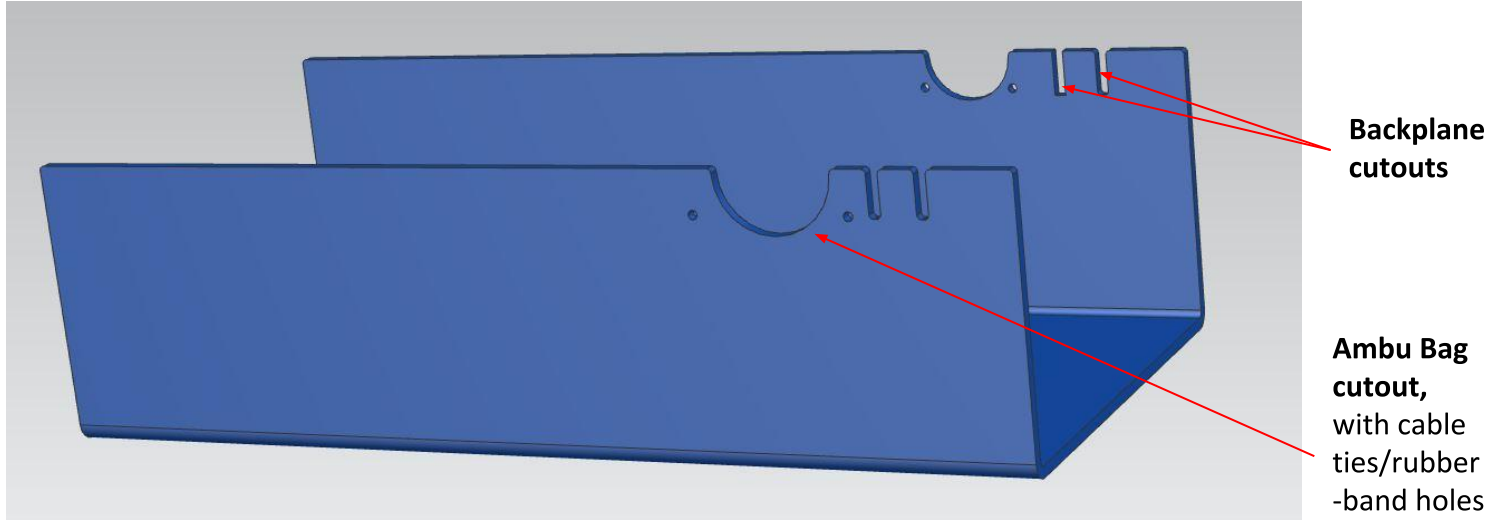
Acrylic Sheet: 5 mm thick with foam padding

This is fastened to the linear guide using 4 screws on the L-bracket

Advantages:

- L-Bracket, Acrylic Sheet available off-the-shelf on various hardware websites
- Easy to manufacture

Component Detail - Enclosure



Material: Acrylic Sheets, 5 mm thickness, Angle brackets to support sidewalls

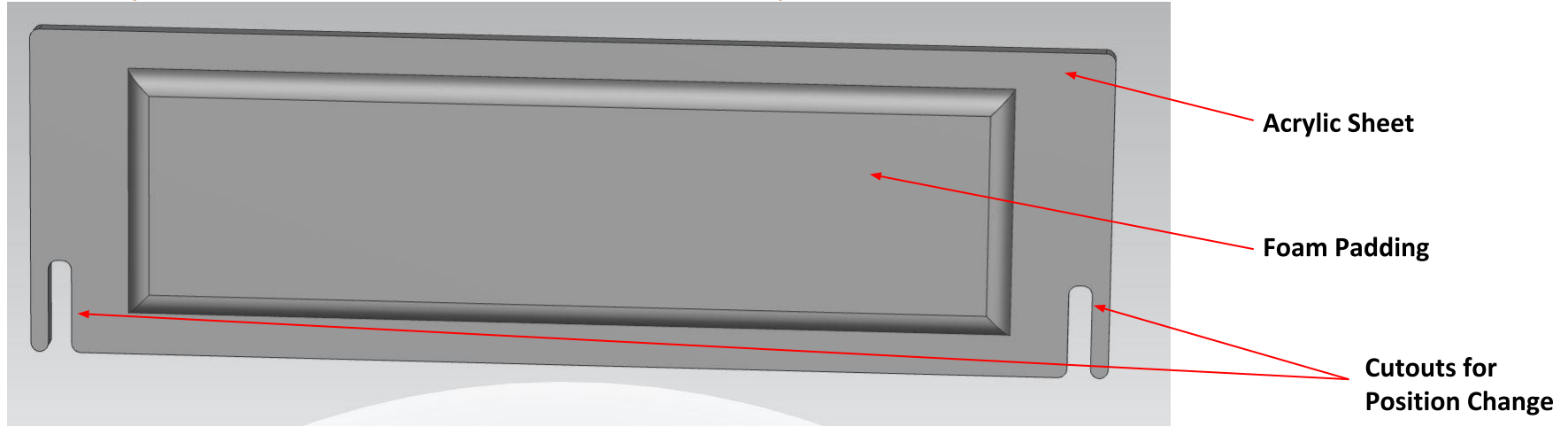
Specs: Approx. 450mm X 125 mm X 223mm

Features:

- Adjustable Backplane position to accommodate smaller Ambu bags
- Cutouts designed as per selected Ambu Bag and Linear Guide Dimensions
- Different Sized Ambu Bag held in place securely using cable ties passed through the cutout holes

Advantages: Easy to Manufacture, No dust or debris suitable for hospital environment

Component Detail - Backplane



Material: Acrylic Sheets, 5 mm thickness

Specs: Approx. 225 mm X 70 mm

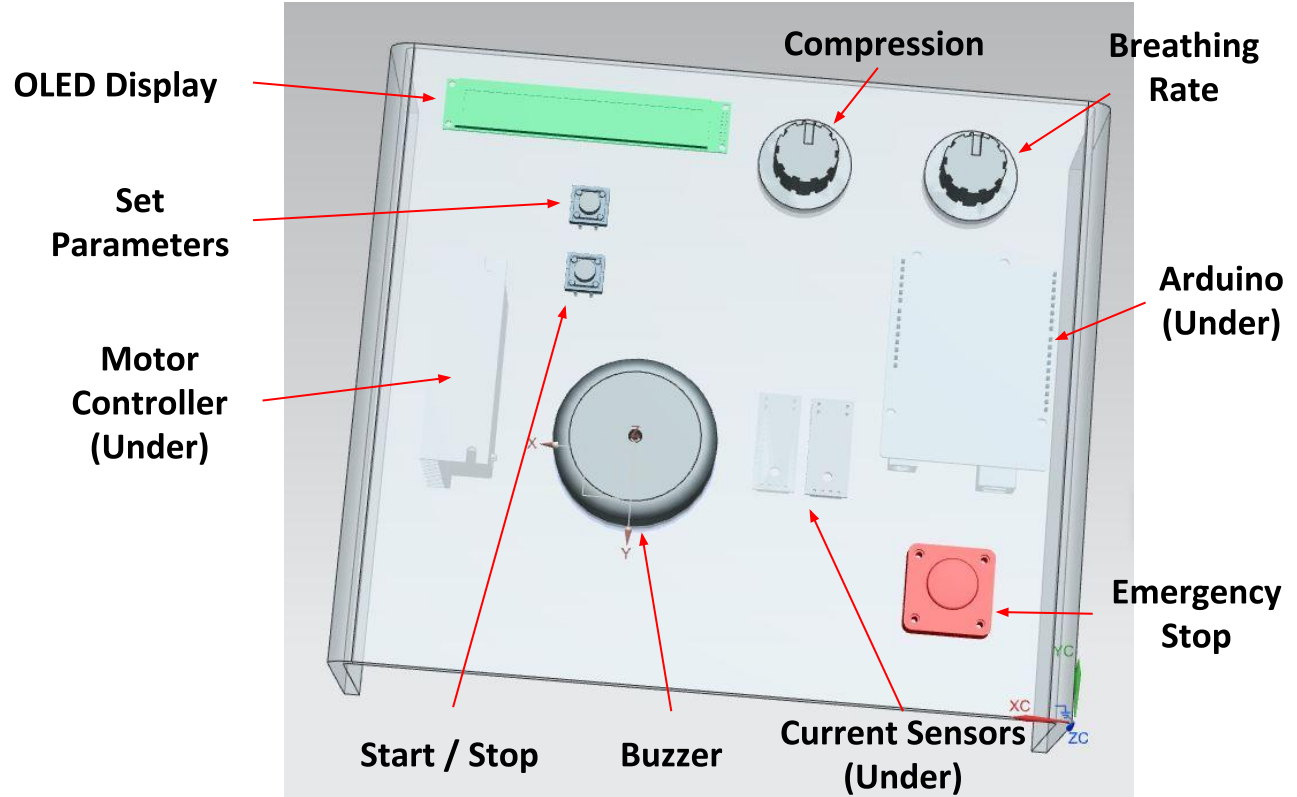
Features:

- Adjustable Backplane position to accommodate smaller Ambu bags
- Cutouts designed as per selected Ambu Bag and Linear Guide dimensions

Advantages: Easy to Manufacture

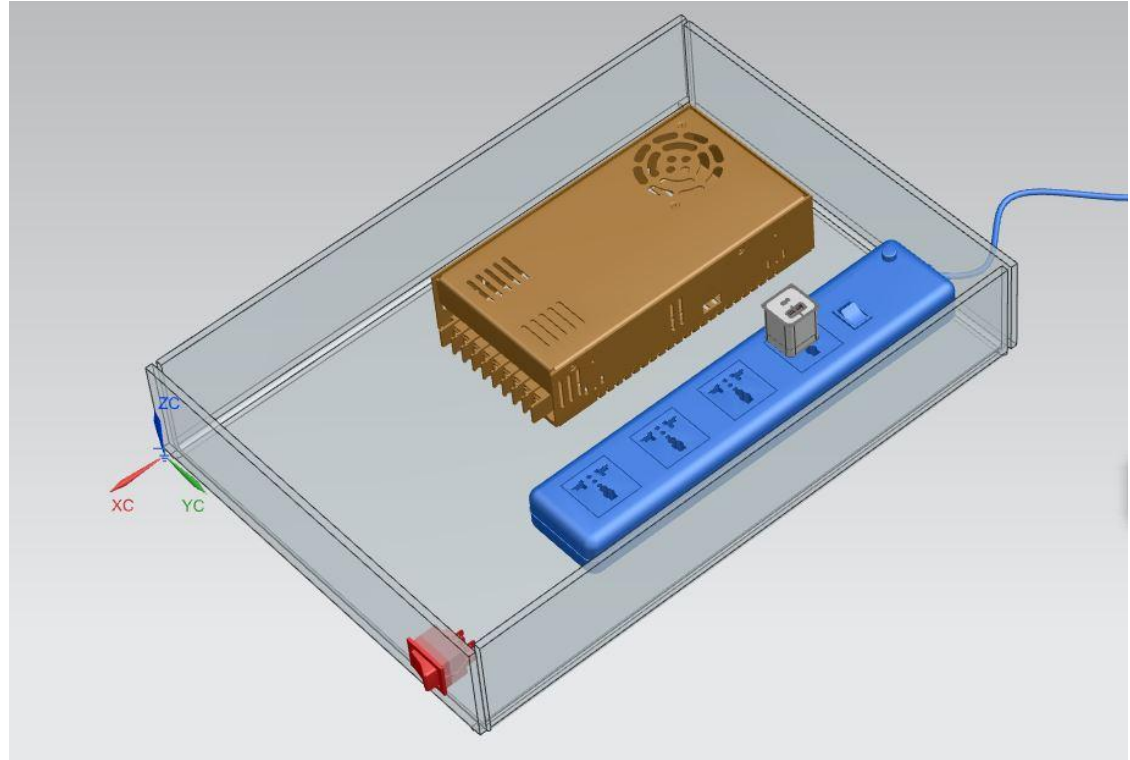
Component Detail - User Interface Electronics Panel

- Momentary buttons for starting and stopping the mechanism as well as applying new settings
- Potentiometer dials for fine grain adjustment of Compression and Breathing Rate
- Emergency stop for safety
- OLED display for settings verification
- Redundant current sensor for pressure drop detection
- Buzzer for auditory feedback of pressure drop or other system failure



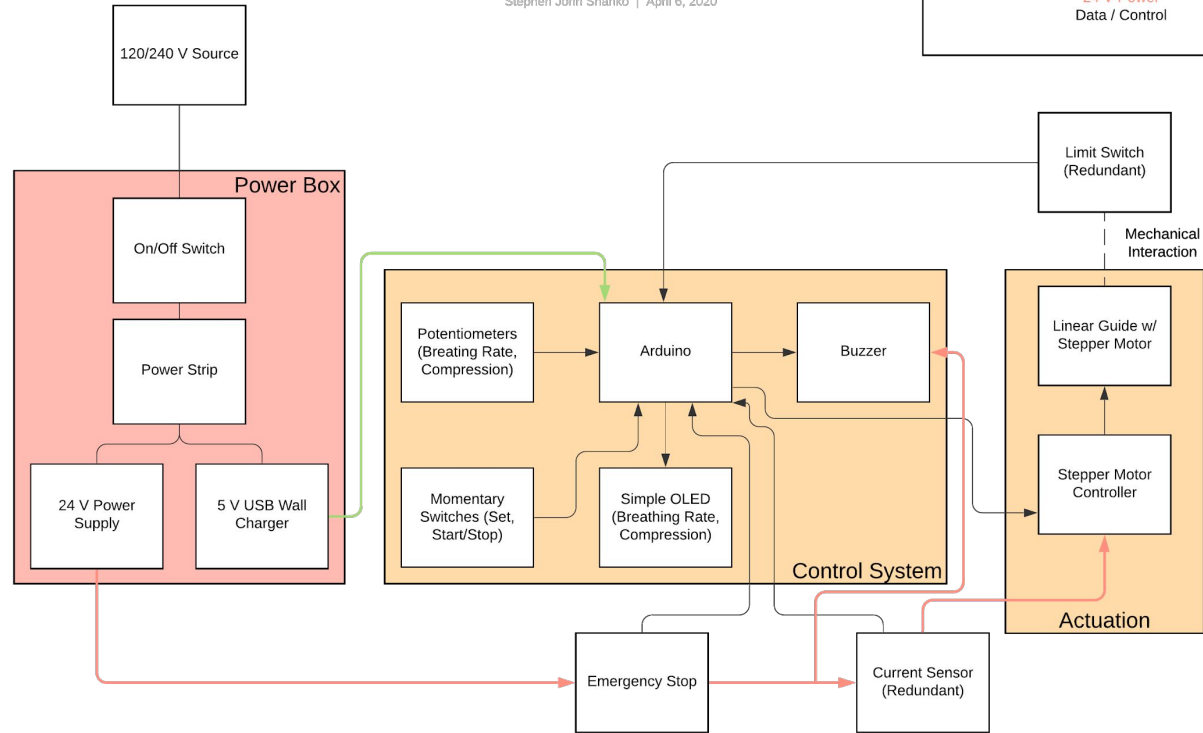
Component Detail - Power Cabinet

- Dedicated power conversion box for safety
- Household materials except for 24V DC supply
- On/Off switch
- Supplies 5V, 24V DC power to control system and motor



Electrical - System

- Simple household and industry standard power components
- 120VAC/240VAC compatible
- Simple display + controls which are easily sourced
- Redundant limit switch for mechanism protection
- Redundant current sensor for leak detection
- Reliable and simple Arduino microcontroller



<https://www.lucidchart.com/invitations/accept/662df293-888f-4b63-a903-dcfa0ff7d38e>

Specifications

- **Operations**

- 0 - 30 pumps per minute*
- 20 lb maximum force*
- 0 - 7.5 inch compression

- **Controls**

- Main power switch - controls all electric input
- Start/stop button - controls start/stop of operation (stop => motor return to 0)
- Abnormal operation/pressure drop sensing capability - with buzzer for alarm
- Emergency stop button
- Set parameters button prevents accidental modification
- 120/240 V AC in and power conversion housed in separate enclosure

**Actual performance may vary based on specific motor and linear guide available*

Assembly

- **Number of parts:** 33
- **Total cost of parts:** \$588.25
- **Additional tools required:** Saw, screwdriver, soldering iron, solder, wire stripper/pliers, drill, razor knife
- **Time required:** 40 hours first attempt, 8 hours once detailed instructions are verified

Mechanical Parts List

Color Key

Steve already has

Not critical for prototype

#	Part/Material	Qty	Design Specs	Cost per Unit	Default Source	Source Link
1	Frame (5mm Acrylic Sheet)	1	450x125x223 mm	N/A	Refer Part 13	N/A
2	Backplane (5mm Acrylic Sheet)	1	225mm X 70 mm	N/A	Refer Part 13	N/A
3	Linear Guide Ball Screw	1	Travel : 200mm; Max Load = 40-50 lbs; Max Speed = 150mm/s	\$98.86	eBay	eBay
4	Ambu Bag	1	Adult	\$25.94	AED Superstore	Source
5	Foam Padding	1	Cut according to need	\$5.75	Amazon	Amazon
6	L Bracket (Steel)	2	Steel 75x60x55 mm	\$8.56	Home Depot	Home Depot
7	Epoxy	2	N/A	\$10.94	Home Depot	Home Depot

Mechanical Parts List (contd.)

Color Key

Steve already has

Not critical for prototype

#	Part/Material	Qty	Design Specs	Cost per Unit	Default Source	Source Link
8	Electronics Panel	1	Acrylic Sheet 5mm Cut to Size	N/A	Refer Part 13	N/A
9	M8 Screw	2	N/A	\$2.32 for a pack of 2	Home Depot	Home Depot
10	M8 Nut	2	N/A	\$0.53 per unit	Home Depot	Home Depot
11	M4 Screw	4	N/A	\$0.72 for a pack of 2	Home Depot	Home Depot
12	M4 Nut	4	N/A	\$0.53 for a pack of 2	Home Depot	Home Depot
13	Acrylic Sheet	1	36" x 72" x .22"	\$156	Home Depot	Home Depot
	Mech Subtotal			\$286.29		

Electronics Parts List

Color Key

Steve already has

Not critical for prototype

#	Part/Material	Qty	Specs	Total Cost	Default Source	Source Link
1	Arduino MEGA	1	Microcontroller	\$16.98	Amazon	Aurdino MEGA
2	DC Stepper Controller	1	4.2A 20-50 VDC Stepper controller	\$38.99	Amazon	DC Stepper Controller
3	Breadboard Jumpers	1	120 pcs	\$6.49	Amazon	Breadboard Jumpers
4	Current Sensor	1	-20 to 20A 100mV / A - 3 pack	\$9.99	Amazon	Current Sensor
5	Buzzers	1	5 pack	\$8.99	Amazon	Buzzers
6	Potentiometers	1	10K Ohm - 5 pack	\$5.99	Amazon	Potentiometers
7	Limit Switches	1	10 pack	\$7.99	Amazon	Limit Switches
8	Power Strips	1	2 pack	\$11.99	Amazon	Power Strips

Electronics Parts List (cont'd)

Color Key

Steve already has

Not critical for prototype

#	Part/Material	Qty	Specs	Total Cost	Default Source	Source Link
9	USB Wall Chargers	1	2.1A - 2 pack	\$9.99	Amazon	USB Wall Chargers
10	24 V Power Supply	1	24VDC 15 A	\$29.95	Amazon	24 V Power Supply
11	16 AWG Stranded	1	100 ft for motor power	\$9.85	Amazon	16 AWG Stranded
12	22 AWG Solid	1	180 ft for logic signals	\$15.99	Amazon	22 AWG Solid
13	Zip ties	1	assorted - 250 pack	\$11.99	Amazon	Zip ties
14	I2C OLED Displays	1	1" - 2 pack	\$10.99	Amazon	I2C OLED Displays
15	22 AWG Stranded	1	138 ft for logic signals	\$14.99	Amazon	22 AWG Stranded
16	Momentary Switches	1	12 pack	\$7.99	Amazon	Momentary Switches
17	Latching Switches	1	12 pack	\$6.99	Amazon	Latching Switches

Electronics Parts List (cont'd)

Color Key

Steve already has

Not critical for prototype

#	Part/Material	Qty	Specs	Total Cost	Default Source	Source Link
18	Extension Cord	1	25'	\$11.98	Amazon	Extension Cord
19	Stepper Motor	1	Nema 23 4.2A 3.0Nm 8mm shaft	\$33	Amazon	Stepper Motor
20	Rocker Switches	1	SPST 10A / 125V - 15 pack	\$6.99	Amazon	Rocker Switches
21	E-Stop Switches	1	1 NO 1 NC - 2 pack	\$10.99	Amazon	E-Stop Switches
22	Main Power Switch	1	N/A	\$6.42	Amazon	Main Power Switch
23	Long USB Cable	1	16ft	\$6.44	Amazon	Long USB Cable

Color Code	Non-Critical Items	Critical Items	Elec Subtotal
Steve already has	\$65.92		
Not critical for prototype	\$55.45	\$180.59	\$301.96

Caveats

- Use of easily accessible materials means there may be a lower level of performance as compared to using more customized equipment
- Variability of enclosure size is based on the particular linear guide that can be procured
- While simplicity and sourceability of electrical components is high, this design will result in more low-level wiring
- Exact level of correspondence between measured current and system pressure for pressure sensing is untested

Requested Funding

Estimated parts cost is roughly \$600 but we anticipate additional potential costs for shipping, tools, and additional misc items to be up to \$400, as we revise the design during fabrication. We estimate that our prototype can be achieved within a cost of \$1000, subject to future adjustments.

References

<https://e-vent.mit.edu/>

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<https://www.gtech.co.uk/ventilators>

<https://news.utexas.edu/2020/04/01/solving-the-ventilator-shortage-with-windshield-wiper-parts/>

<https://www.youtube.com/watch?v=OOu1ABEAPaU>

https://www.youtube.com/watch?v=jutBw_xlwTw

<https://www.youtube.com/watch?v=oLQ5bXakWq8>

<https://youtu.be/HRqLUAvY7io>

<https://www.youtube.com/watch?v=US7JeW2uynM>

Stay Home
Stay Safe